This document is intended to facilitate stakeholder feedback at the May 31, 2016 ITR Interim Medium- and Heavy-Duty Vehicle Hybrid Technology Emission Test Procedures Work Group meeting. This document is only intended to encourage stakeholder feedback, is incomplete, and should not be construed as a formal regulatory proposal.

POTENTIAL INNOVATIVE TECHNOLOGY REGULATION: DRAFT INTERIM MEDIUM- AND HEAVY-DUTY VEHICLE HYBRID TECHNOLOGY EMISSION TEST PROCEDURES

A. APPLICABILITY

These test procedures apply to the following:

1. New 2017 and subsequent model year (MY) heavy-duty hybrid motor vehicles with a gross vehicle weight rating (GVWR) greater than 14,000 lbs and engines used to power these vehicles, for which a manufacturer requests certification compliance flexibility pursuant to title 13, California Code of Regulations (CCR) § 2208 and § 2208.1; and
2. California Air Resources Board (ARB) certification, pursuant to title 13, CCR § 2208 and § 2208.2, of a hybrid conversion system to be installed on any for the following:
    (a) A 2007 or newer MY ARB-certified non-hybrid Class 2a base vehicle that achieves at least 35 miles all-electric range (AER) when converted with the applicable hybrid system; or
    (b) a 2007 or newer MY ARB-certified non-hybrid medium-duty base vehicle; or
    (c) a 2010 or newer MY ARB-certified non-hybrid heavy-duty base engine.

For new heavy-duty engines, these interim test procedures supplement, and do not replace, California's general procedures and requirements necessary to certify a heavy-duty engine for sale in California set forth in "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles", as incorporated in title 13, CCR, §1956.8(b), "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Otto-Cycle Engines, as incorporated in title 13, CCR §1956.8(d), for testing and compliance of heavy-duty diesel and Otto-cycle engines with exhaust emission standards. For new hybrid heavy-duty motor vehicles, these interim test procedures supplement, and do not replace, the "California Interim Certification Procedures for 2004 and Subsequent Model Hybrid-Electric and Other Hybrid Vehicles, in the Urban Bus and Heavy-Duty Vehicle Classes" (December 12, 2013), as incorporated in title 13, CCR, §1956.8.

B. DEFINITIONS

These interim test procedures incorporate by reference the definitions and abbreviations set forth in 40 Code of Federal Regulations (CFR), Chapter I, Subchapter U, Part 1065 (Engine Testing Procedures), California Interim Certification Procedures for 2004 and Subsequent Model Hybrid-Electric and Other Hybrid Vehicles, in the Urban Bus and Heavy-Duty Vehicle Classes (Amended December 13, 2013), and California's

Innovative Technology Regulation as set forth in CCR § 2208, unless otherwise amended below.

"55 Mile Per Hour (mph) Cruise Cycle" means the procedure described in 40 CFR Title 40, Chapter I, Subchapter U, Subpart F, 1037.510 (a).

"Heavy-duty Urban Dynamometer Drive Cycle (UDDS)" means the procedure described in 40 CFR Title 40, Chapter I, Subchapter C, Part 86, Appendix I.

"Orange County Bus Cycle" means the procedure described in Appendix C of ARB's *Staff Report: Initial Statement of Reasons – Proposed Modifications to the Public Transit Fleet Rule and Interim Certification Procedures for Hybrid Electric Urban Transit Buses*; September 6, 2002; http://www.arb.ca.gov/regact/bus02/appc.pdf .

"Positive Kinetic Energy" or "PKE" means (1/distance) * ∑[(final velocity)^2 – (initial velocity)^2)], in miles/second^2, when final velocity is greater than initial velocity evaluated on a one Hertz basis.

"SC03 Supplemental Federal Test Procedure" means the procedure described in 40 CFR Title 40, Chapter I, Subchapter C, Part 86, Appendix I.

C. GENERAL REQUIREMENTS

Only new heavy-duty hybrid engines and hybrid conversion systems for medium- and heavy-duty vehicles and engines that demonstrate no oxides of nitrogen (NOx), carbon monoxide (CO), hydrocarbon (HC) emissions increase and at least a 10 percent carbon dioxide (CO_2) emissions reduction pursuant to these test procedures are eligible for certification pursuant to the Innovative Technology Regulation (CCR § 2208, 2208.1, and 2208.2). These interim test procedures identify allowable methodologies for measuring this hybrid technology's emissions performance as needed to determine Innovative Technology Regulation eligibility. A hybrid conversion system must also demonstrate no evaporative emissions increase as required by these test procedures to be eligible for certification pursuant to the Innovative Technology Regulation.

1.1 New Heavy-duty Hybrid Engines. Exhaust emissions from new heavy-duty engines must be conducted pursuant to section D, section E, or section F of these test procedures. A compression ignition engine may be exempted from CO and/or HC exhaust in-use emission compliance evaluation pursuant to sections D, E, or F if the manufacturer demonstrates to the satisfaction of the Executive Officer that emissions of said pollutant(s) are inherently low and unlikely to be impacted due to the hybrid driveline. This demonstration may be based upon data and other information provided by the manufacturer, including engine certification data, and an engineering evaluation of the engine and hybrid system.

1.2 Hybrid Conversion System Tier 1 Certification. A manufacturer applying for Tier 1 certification of a hybrid conversion system pursuant to CCR § 2208.2 must demonstrate, based upon sound principles of science and engineering and/or independent, verifiable data, that the hybrid conversion system meets these test procedure's exhaust emissions criteria when installed on any base engine, vehicle or chassis to be included in said certification.

1.3 Hybrid Conversion System Tier 2 or Tier 3 Certification. A manufacturer applying for Tier 2 or Tier 3 certification of a hybrid conversion system pursuant to CCR § 2208.2 must demonstrate that the hybrid conversion system meets these test procedure's exhaust emissions criteria when installed on any base engine, vehicle or chassis to be included in said certification, as follows:

a) For conversion of a base engine or vehicle between 6,001 and 14,000 lbs GVWR, a hybrid conversion system must demonstrate compliance with these test procedures emissions criteria via emissions testing conducted pursuant to section E.
b) For conversion of a base engine over 14,000 lbs GVWR, a hybrid conversion system may demonstrate compliance with these test procedures emissions criteria via emissions testing conducted pursuant to section D or section E.

2. Emission Test Plan. An applicant must provide a Hybrid Technology Emission Test Plan for Executive Officer review at least 60 days prior to conducting emission testing pursuant to these emission test procedures. This plan must include a description of the proposed vehicles to be tested, testing equipment to be used, proposed emission test procedures and other information needed to determine whether proposed emission testing meets the requirements of these Interim Medium- and Heavy-Duty Vehicle Technology Emission Test Procedures. At a minimum, the Hybrid Technology Emission Test Plan must include the following elements:

a) Contact Information: Identification of the business contact person, business phone number, physical business address, and business e-mail address of the responsible party submitting the application.
b) Proposed Logistical Information: Proposed test date(s), location(s) or test facilities, and entity conducting the testing. ARB reserves the right to have its employee(s) or representative(s) present during emission testing.
c) Proposed Base and Hybrid Engine Information: Make, model and model year; anticipated mileage at test start; fuel used; displacement (L); aspiration; maximum power (kW) and torque (Nm); emission aftertreatment technology; California NOx, HC or total hydrocarbon, and CO certification level; and family emission limit (FEL).
d) Proposed Base and Hybrid Vehicle Information: Curb weight, gross vehicle weight rating, average loaded vehicle weight and test weight; anticipated mileage at test start; drive train description; and California NOx, HC or total hydrocarbon, and CO certification level.

e) Proposed Hybrid Energy Storage System(s) Information: Battery description, including specific energy, battery pack voltage, number of battery modules, and an estimate of battery pack cycle life. The manufacturer shall describe the battery management system, battery pack thermal management strategy (active or passive cooling), the weight of each battery module, the weight of the battery pack (including removable pack structures), and any energy storage devices in addition to batteries, such as ultra-capacitors, flywheels, hydraulic assist devices, or other energy storage technologies.
f) Proposed Operation of Mechanical and Electrical Accessories: Description of the base and hybrid vehicle's mechanical and electrical accessories and their proposed usage during emission testing.

2.1 Applicants proposing to conduct PEMS testing pursuant to section D must also include the following:

a) Proposed Equipment: For emission testing conducted pursuant to section D, description of equipment to be used for measuring required engine and vehicle operating parameters, exhaust emissions, location, and elevation.
b) Proposed Test Route: Test route description, including route distance (miles); average anticipated vehicle speed , including idle (miles per hour, mph); maximum anticipated vehicle speed (mph); anticipated idle time (minutes); anticipated average PKE; minimum elevation (feet above sea level); maximum elevation (feet above sea level), maximum and average route grade, and aerial map of proposed test route.
c) Defining a Valid Test Run: Description of the applicant's proposed allowable average speed and PKE variability among test runs, and justification for proposed variability if it exceeds the ARB recommended variability described in section D. 2.1.

2.2 An applicant proposing to conduct chassis dynamometer emission testing pursuant to section E that proposes to utilize an alternate duty cycle in lieu of a duty cycle identified in section E, 2. must indicate why the proposed alternate duty cycle is likely to better represent the hybrid vehicle's anticipated in-use activity as operated by California fleets.

2.3 The Hybrid Technology Emission Test Plan must be submitted, at least 60 days prior to the commencement of testing, in a format to be supplied by the Executive Officer. The Executive Officer will review the Hybrid Technology Emission Test Plan within 30 days of its receipt and either: 1) approve the plan, at which point emission testing conducted pursuant to the plan and these test procedures may commence; 2) disapprove the plan, and indicate the reason(s) for disapproval; or 3) request additional clarifying information.

D. PORTABLE EMISSIONS MEASUREMENT SYSTEM TEST PROCEDURES

Unless otherwise indicated in this section, emission testing shall conform to the on-road testing element of SAE International J1526: Fuel Consumption Test Procedures – Type III (SEPT 2015).

1. Vehicle Selection and Preparation.

When selecting vehicles for testing, the baseline and hybrid vehicle shall be of the same vehicle class and intended vocation, and be identical or as closely matched as possible in model year, engine power and displacement, number of axles and real axle ratios, electrical and mechanical accessories (such as power steering, brakes, etc…), body style and external surface contours, aerodynamic configuration, wheel circumference, rear differential, gearing, and accessories, unless a difference between the base and hybrid vehicle in one of the above variables is directly related to the effective functioning of the hybrid vehicle's hybrid system. For example, the power and displacement of a baseline vehicle's engine may be higher than that for a hybrid vehicle if the hybrid vehicle utilizes a downsized engine as part of its hybridization strategy. In this case, the baseline vehicle would use an engine typical of its vehicle class and vocation, while the hybrid vehicle would use the intended downsized engine.

To be comparable, the baseline and hybrid vehicle must be able to accomplish the same function, with similar performance, utility, and durability attributes. Vehicles shall be tested with the normal appendages (mirrors, bumpers, etc…) and with the same mechanical and electrical accessories in operation that are reflective of the vehicle's anticipated typical power needs. A baseline engine or vehicle may be from a different model year relative to the hybrid vehicle if the engine, after-treatment, and on-board diagnostics system is functionally unchanged between the two model years and if all other vehicle characteristics are substantially similar, with the exception of the hybrid system.

For hybrid conversion systems, the base vehicle and engine used for emission testing shall be the same as that of the hybridized vehicle and engine used for emission testing.

1.1 Mileage. Minimum mileage of baseline and hybrid vehicles for testing shall be as follows:

a) To ensure emission stability, the minimum mileage at the time of testing for both the baseline and hybrid vehicle shall be 4,000 miles. Utility trucks may alternately accumulate a minimum of 125 hours of operation prior to testing, if verified by a non-resettable, vehicle-integrated hour meter.
b) The mileage on all baseline and hybrid vehicles must be within 1,000 miles of each other if the odometer of one vehicle is less than 5,000 miles.

c) The mileage on all vehicles must be within 3,000 miles of each other if the odometer on all vehicles is greater than 5,000 miles but less than 10,000 miles on one vehicle.
d) The mileage on all vehicles must be within 10,000 miles of each other if the odometer on all vehicles is greater than 10,000 miles but less than 30,000 miles on one vehicle.
e) The mileage on all vehicles must be within 50,000 miles of each other if the odometer is greater than 30,000 miles on all vehicles.

1.2 Vehicle Test Weight. Heavy-duty vehicles shall be tested at the prescribed weight identified in ARB's Hybrid Heavy-Duty Vehicle Test Procedures (Amended December 12, 2013) Section D. 1.4.2. Light- and medium-duty vehicle test weight shall be as specified in 40 CFR Part 86.129-94.

1.3 Fuel Specifications. Both base and hybrid vehicles shall use an identical gaseous or liquid fuel, unless a base vehicle using a different fuel is approved in advance by the ARB Executive Officer. If an appropriate base vehicle that utilizes the same fuel type as the hybrid vehicle is unavailable, the Executive Officer may approve use of an alternate base vehicle fuel type that best represents the typical fuel used by a newly manufactured vehicle in the intended vehicle class and vocation. For example, a gasoline powered Class 6 hybrid truck may warrant use of a diesel-fueled Class 6 base truck for the purposes of emission testing, since Class 6 vehicles are typically diesel fueled.

2. Drive Cycle Selection.

The hybrid and base vehicle shall be emission tested over at least four valid runs of the same on-road high speed cruise test route that spends at least 90 percent of its time at 55 miles per hour cruise (± 1 mph). The hybrid and base vehicle shall also be tested over at least four valid runs of the same transient-type test route that has an average driving speed (including idle) of between X and Y miles per hour and a PKE of between X and Y (*tbd*). All test runs should be of approximately 30 minutes in duration with an average grade of less than five percent. Proposed test routes shall begin and end at the same location and may be repeated multiple times to represent a single test run.

A manufacturer may propose, as part of its Hybrid Technology Emission Test Plan, a transient-type test route with differing average speed and/or PKE profile instead of the transient-like route meeting the criteria identified above. The Executive Officer may approve this alternate test route if he or she determines based upon his or her engineering judgement based upon data provided by the applicant that the alternate test route more accurately depicts the hybrid vehicle's anticipated in-use activity as operated by California fleets

Note: For leader-follower emission testing, SAE J1321 requires the hybrid and base vehicle be within 1500 feet of each other, while SAE International J1526 indicates they should conduct their runs within five minutes of each other. While this makes sense for high-speed cruise, such a distance or time differential may result in significant driving variability between the base and hybrid vehicle in a transient-like route. Do stakeholders have suggestions regarding potential leader-follower requirements for a transient-like test route?

2.1 Drive-Cycle Variability. Average driving speed with idle and average PKE are to be used as metrics to determine whether each vehicle is driven as similarly as possible over the proposed high-speed cruise and transient on-road test routes. *Note: ARB recommended variance in these metrics TBD based on evaluation of ARB PEMS test data and upcoming NREL hybrid heavy-duty truck PEMS testing.*

3. Emission Testing.

Requirements for PEMS testing of NOx, HC, CO, and CO_2 exhaust emissions can be found in 40 CFR Part 1065, Subparts C, D, and J. Weight tanks for fuel measurement may be used to verify measured CO_2 exhaust emissions; however, CO_2 exhaust emissions for the purposes of determining with Innovative Technology Regulation compliance shall be calculated based upon emissions directly measured by the PEMS unit utilizing the carbon balance method.

Test cycles shall consider all emission data from the moment the vehicle is started at the beginning of each test run, excluding the actual start event. The hybrid and base vehicles shall be started and warmed to operating temperature utilizing the same test cycle that will be used for emission characterization. This procedure allows for multiple "hot" test events back to back with only a 20 to 30 minute "key off' condition in between each test event. Once the vehicles are at operating temperature, they shall be turned off and will remain in the "key off" position for approximately 20 to 30 minutes. The vehicles shall be restarted and idled for one minute, at which time the test cycle shall begin and emission measurements will be taken. At the end of the test cycle the hybrid and base vehicles shall be returned to the "key off" condition.

For charge depleting hybrids, the hybrid vehicle shall be driven over the drive cycle fully charged and in charge depleting mode until the hybrid vehicle's engine first starts. The hybrid vehicle shall be followed during this charge depleting operation by the base vehicle. After the hybrid vehicle's engine first starts, the vehicles shall complete the test run/loop to the test route starting point, after which emission testing may commence, as described in the paragraph above.

The emission test shall terminate at the conclusion of the test run. However, sufficient idle time should be included at the end of a run, such that the analyzers are not missing emissions that are still in the sampling train. The lag time between when the vehicle

emits the emissions and when the emissions are actually analyzed can be as much as 10 to 20 seconds. As a result, all 30 minute test cycles are expected to have a minimum of one minute idle at the end of the cycle before it terminates.

3.1 Vehicle Pre-Conditioning. Vehicle conditioning must be conducted to minimize the possibility of an infrequent diesel particulate filter (DPF) regeneration event during the emission test runs. The objective of the process will be to minimize hybrid and base vehicle CO_2 and other emission variability due to unplanned regeneration events. The preconditioning may consist of a stationary forced DPF regeneration using a service tool or other passive regeneration methods recommended by the engine or after-treatment manufacturer. If a DPF regeneration occurs during a run the run will be invalid and shall be removed from the test data set. If the user lacks the capability to monitor appropriate regeneration messages over the controlled area network (CAN) data bus, the exhaust temperature across the DPF should be measured to determine occurrence of a DPF regeneration as indicated by a sustained temperature increase across the DPF.

3.2 Net Energy Change. Net energy change calculations and variance determinations, and state of charge correction procedures shall conform to SAE International's Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles J2711 SEP2002.

3.3 Charge-Depleting Hybrid-Electric Vehicles. A charge-depleting hybrid electric vehicle shall be emission tested in charge sustaining mode, from the point at which the engine first turns on at the end of the vehicle's AER.

3.4 Emissions Calculations. Exhaust emissions are calculated as follows:

Average mass-based (grams per mile) emissions are first calculated, as adjusted for net energy change, for each of the following:

a) Hybrid vehicle as driven over the high-speed cruise route ($A_{HybridCruise}$)
b) Non-hybrid base vehicle as driven over the high-speed cruise type test route ($A_{BaseCruise}$)
c) Hybrid vehicle as driven over transient-like cycle ($A_{HybridTransient}$)
d) Non-hybrid base vehicle as driven over transient-like cycle ($A_{BaseTransient}$)

Average mass-based emissions for each = $(E_1 + E_2 + E_3 + \ldots E_n)/n$

Where E_n = grams per mile emissions from the n^{th} valid test run and
n = number of runs

Average weighted emissions are then calculated as:

Average weighted hybrid emissions (A_{Hybrid}) =

$$(A_{HybridCruise} * 0.18) + (A_{HybridTransient} * 0.82)$$

Average weighted base vehicle emissions (A_{Base}) =

$$(A_{BaseCruise} * 0.18) + (A_{BaseTransient} * 0.82)$$

3.4.1 Criteria Pollutant Pass-Fail Determination. For each measured criteria pollutant, if $A_{Hybrid} \leq (A_{Base} * 1.10)$, where 1.10 reflects a 10 percent test allowance, then the hybrid vehicle is found to not increase emissions of that pollutant. If $A_{Hybrid} > (A_{Base} * 1.10)$ for NOx, CO, or HC, then the hybrid vehicle has failed the emission test. A manufacturer wishing to repeat the emissions test must first submit a new emission test plan pursuant to these emission test procedures for Executive Officer approval.

3.4.2 CO_2 Emission Pass-Fail Determination. Percent CO_2 emission reduction is calculated as:

$$\text{Percent } CO_2 \text{ Reduction} = ((A_{Base} - A_{Hybrid})/A_{Base}) * 100$$

Vehicles with AER. For a Class 2a hybrid vehicle with AER, a manufacturer may apply an additional utility factor (UF) to average weighted hybrid CO_2 emissions:

$$A_{Hybrid} = ((A_{HybridCruise} * 0.18) + (A_{HybridTransient} * 0.82)) * (1 - UF(D))$$

Where UF(D) is the utility factor for a vehicle that achieves at least D miles AER. For a Class 2a vehicle, UF(D) shall be determined according to SAE International's Surface Vehicle Information Report J2841 SEP2010 (SAE J2841), incorporated by reference herein, from the Fleet Utility Factors (FUF) Table in Appendix B or using a polynomial curve fit with "FUF Fit" coefficients from Table 2 Utility Factor Equation Coefficients.

A manufacturer may propose a utility factor for a medium- or heavy-duty hybrid vehicle with AER as part of its Hybrid Technology Emission Test Plan to be calculated as the FUF pursuant to SAE J2841 procedures and based upon electronic in-use daily mileage data for the proposed hybrid heavy-duty vehicle class and vocation. The Executive Officer may approve, deny, or adjust the proposed UF based upon his or her engineering judgement and evaluation of this and other available relevant data and information.

E. CHASSIS DYNAMOMETER TEST PROCEDURES

Unless otherwise indicated in this section, hybrid and base vehicle emission testing shall confirm to the requirements of California Interim Certification Procedures for 2004

and Subsequent Model Hybrid-Electric and Other Hybrid Vehicles, in the Urban Bus and Heavy-Duty Vehicle Classes (Amended December 13, 2013), Section D.

1. Measurements. All equipment specifications, measurement principles, verification requirements, and emissions measurement, calibration, and verification methodologies are provided in 40 CFR Part 1065.

2. Vehicle Selection. The applicant shall propose a base vehicle for chassis dynamometer testing pursuant to the base vehicle selection criteria identified in section D. 1 of these test procedures.

3. Duty Cycle Selection. The hybrid and baseline vehicle shall each be tested over two duty cycles reflective of transient-like and high-speed cruise operation. Class 2a or medium-duty vehicles shall be tested over the SC03 Supplemental Federal Test Procedure to represent transient-like operation. Heavy-duty vehicles shall be tested over the heavy-duty Urban Dynamometer Drive Cycle (UDDS) to represent transient-like operation, with the exception of transit buses which shall use the Orange County Bus Cycle. All vehicles shall be tested over the 55 mph Cruise Cycle to represent high-speed cruise operation.

A vehicle with ePTO may conduct chassis-dynamometer emission testing pursuant to the hybrid-PTO test procedures defined in 40 CFR 1037.525 in lieu of the specified transient-like duty cycle. A manufacturer may propose, as part of its Hybrid Technology Emission Test Plan, an alternate duty cycle in lieu of the transient-like duty cycles identified in this section. The Executive Officer may approve this alternate duty cycle if he or she determines based upon his or her engineering judgement data provided by the applicant that the alternate duty cycle more accurately depicts the hybrid vehicle's anticipated in-use activity as operated by California fleets.

4. Charge-Depleting Hybrid-Electric Vehicles. A charge-depleting hybrid electric vehicle shall begin in charge sustaining mode, from the point at which the engine first turns on at the end of the vehicle's AER.

5. Emissions Calculations. Exhaust emissions are calculated as follows.

Average mass-based (grams per mile) emissions are first calculated for each of the following:

a) Hybrid vehicle on the transient duty-cycle (A_{H-T})
b) Non-hybrid base vehicle on the transient duty-cycle (A_{B-T})
c) Hybrid vehicle on the high-speed cruise duty-cycle (A_{H-C})
d) Non-hybrid base vehicle on the high-speed cruise duty-cycle (A_{B-C})

Average weighted mass-based emissions for each = $(E_1 + E_2 + E_3 + \ldots E_n)/n$

Where E_n = grams per mile emissions from the nth valid test run and
n = number of runs

Average weighted emissions are then calculated as:

Average weighted hybrid emissions (A_{Hybrid}) = ($A_{H\text{-}T}$ * 0.82) + ($A_{H\text{-}C}$ * 0.18)
Average weighted base vehicle emissions ($A_{Baseline}$) = ($A_{B\text{-}H}$ * 0.82) + ($A_{B\text{-}C}$ * 0.18)

Criteria pollutant and CO_2 emission pass-fail determinations are conducted pursuant to section D. 3.4.1 and 3.4.2 of these test procedures, respectively.

F. POST-TRANSMISSION POWERTRAIN VEHICLE SIMULATION

A hybrid vehicle certifying to meet Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Vehicles – Phase 1 pursuant to 40 CFR Chapter I, Subchapter U, 1037.555 may use the post-transmission powertrain vehicle simulation emissions data derived pursuant to said certification testing to also demonstrate CO_2 emission compliance for the purposes of CCR § 2208.1. Such a vehicle that concurrently measures and calculates NOx, CO, and HC in the identical fashion as done for CO_2 emissions pursuant to 40 CFR Chapter I, Subchapter U, 1037.555 may use the NOx, CO, and HC emissions data derived pursuant to said certification testing to also demonstrate NOx, CO, and HC emission compliance for the purposes of CCR § 2208.1. In such case, the percent CO_2 reduction is calculated as follows:

Percent CO_2 reduction = IF * 100

Where

IF = the CO_2 Improvement Factor calculated pursuant to 40 CFR 1037.615.

For each measured criteria pollutant, if (Emission Rate A * 1.10) $\geq$ Emission Rate B, where Emission Rates A and B have the meanings described in 40 CFR Chapter I, Subchapter U, 1037.615(b)(2)(iii), then the hybrid vehicle is found to not increase emissions of that pollutant.

G. EVAPORATIVE EMISSION TEST REQUIREMENTS

A hybrid conversion system must demonstrate that it will not increase evaporative emissions from the base vehicle.

1. Light- and Medium-Duty Vehicle Conversions. A manufacturer of a hybrid conversion system for a base vehicle of less than 14,000 lbs GVW shall demonstrate

that the converted vehicle meets the evaporative emissions standard to which the base vehicle was originally certified by conducting the three-day diurnal evaporative procedure emissions test as specified in the "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Motor Vehicles", amended on December 6, 2012.

2. Heavy-Duty Engine Conversions. A manufacturer of a hybrid conversion system for a base vehicle of 14,000 lbs GVW or more may provide an engineering evaluation demonstrating that the conversion system does not increase evaporative emissions from the base vehicle in lieu of the three-day diurnal evaporative procedure emissions test.

3. Compression-ignition Engines and Sealed Fuel Systems. A converted vehicle with a compression ignition engine or a sealed fuel system that can demonstrate no evaporative emissions is exempt from evaporative emissions testing. This demonstration may be based upon an engineering evaluation of the base vehicle and hybrid conversion system and data submitted by the conversion system manufacturer in a format to be supplied by the Executive Officer, and must show that the converted vehicle has no evaporative-related emissions under normal operation. Any such demonstration must be approved by the Executive Officer in order to confirm the converted vehicle is exempt from evaporative emission testing.

H. ALL-ELECTRIC RANGE DETERMINATION

A hybrid vehicle's AER shall be defined as the distance the vehicle travels electrically (with the engine off) before the engine turns on for the first time, after the battery has been fully charged, as described in this section. The vehicle shall be tested for all-electric range in default mode or in normal mode if the vehicle does not have a default mode.

PEMS Tested Vehicles. A vehicle that conducts PEMS testing pursuant to section D shall demonstrate its AER over the transient-like test route used to demonstrate emissions compliance. The AER range test shall begin at the same location as emission testing commenced for the transient-like route. The location at which the engine first turns on must be captured by the GPS system, and distance traveled identified by the vehicle odometer or other mechanism to be approved by the Executive Officer. The altitude at the start of the test and the point the engine first turns on must be recorded, and the location the engine first turns on may not be more than 100 feet lower altitude than the starting location. ARB recommends that the starting point of such a test route be no more than 100 feet higher elevation than the lowest point in the route to avoid the possibility of invalid AER determinations.

1. Other Vehicles. A vehicle that demonstrates it meets these test procedure's emissions criteria pursuant to section E shall demonstrate its AER on the chassis

dynamometer over either the Orange County Drive Cycle or the heavy-duty UDDS cycle, commencing with the beginning of the duty cycle. AER for a vehicle that demonstrates it meets these test procedure's emissions criteria pursuant to section F shall be based upon the simulated distance the vehicle travels before the engine first turns on pursuant tot the required post-powertrain vehicle simulation.

I. DATA COLLECTION AND QUALITY CONTROL

(under development)

The following data must be collected (from SAE J1939 broadcast data, analog instrumentation, field records, or manufacturer information/specification sheets) for all baseline and hybrid vehicles participating in PEMS testing. If proprietary equipment or information is needed to collect these signals, the applicant shall make this equipment or information available to ARB upon request if needed for the purposes of confirmatory testing.

The actual signal value shall always be used instead of a default or limp home value. For purposes of the calculated load, torque, fuel rate, and modeled exhaust flow parameters, manufacturers shall report the most accurate values that are calculated within the applicable electronic control unit (e.g., the engine control module). "Most accurate values", in this context, shall be of sufficient accuracy, resolution, and filtering to be used for the purposes of in-use emission testing with the engine still in a vehicle (e.g., using PEMS).

The following data are to be collected from the engine control unit (ECU):

- Engine Torque
- Engine Speed
- Rechargeable Energy Storage System Battery State-of-Charge (if applicable)
- Rechargeable Energy Storage System Net Energy Change (if applicable)
- Boost Pressure
- Coolant Temperature
- Intake Manifold Temperature
- Fuel Injection Rate
- Fuel Temperature
- Fault Status
- Vehicle Speed. (X, Y, Z, T position as a factor of time shall be measured by GPS and calibrated with ECU-measured speed to ensure ability to continuously measure and/or extrapolate vehicle speed during test runs)

The following data are to be collected by global positioning system (GPS):

- Vehicle Speed
- Vehicle Position (X, Y, Z)
- Elevation

Vehicle speed may also be determined based upon a calibrated wheel-based measurement.

Additional required data and default measurement technique are identified below:

- Intake Air Flow Rate - Flow Sensor
- Exhaust Mass Flow - Exhaust Flow Sensor (Pitot)
- Exhaust Back Pressure - Pressure Sensor
- Exhaust Temperature at Aftertreatment System Inlet and Tailpipe - Temperature Sensor
- Ambient Humidity – Humidity Sensor
- Ambient Temperature – Temperature Sensor
- Ambient Pressure – Pressure Sensor

NOx, CO, CO_2, CH_4, and other hydrocarbon emissions are to be measured by the PEMS unit. Fuel consumption of the hybrid and baseline vehicle shall be calculated based mass balance of carbon-bearing emission gases as described in 40 CFR Part 86 and SAE test method J1094a.

1. Emission Test Results. Format for reporting emission test results under *development*

The manufacturer must describe, as part of its Emission Test Report, all test runs conducted during the days of emission testing as identified on the Hybrid Technology Emission Test Plan, including test runs that are not included in emissions calculations and the reason(s) their exclusion.